CLAIMS

What is claimed is:

1. A fiducial pattern comprising:

a circular main fiducial; and

an auxiliary fiducial encompassed by the circular main fiducial, wherein the auxiliary fiducial is rotationally asymmetric with respect to the circular main fiducial.

2. The fiducial pattern of Claim 1, wherein the circular main fiducial is a first color and the auxiliary fiducial is a second color.

3. The fiducial pattern of Claim 1, wherein the auxiliary fiducial is a polygon.

4. The fiducial pattern of Claim 1, wherein the auxiliary fiducial is a rectangle.

5. The fiducial pattern of Claim 1, wherein the auxiliary fiducial is circular.

6. The fiducial pattern of Claim 1 mounted on a portable computing platform.

7. The fiducial pattern of Claim 1, mounted on a turntable.

8. A multiple fiducial pattern comprising:

a first circular main fiducials arranged on a grid;

a second circular main fiducial arranged on the grid,
wherein the second main fiducial is distinguishable from the
first main fiducial; and

a third circular main fiducial arranged on the grid;
wherein, the third circular main fiducial is distinguishable
from the second circular main fiducial and the first main
fiducial.

9.   The multiple fiducial pattern of Claim 8, wherein the
first circular fiducial is a first color, the second circular
fiducial is a second color, and the third circular fiducial is a
third color.

10.   The multiple fiducial pattern of Claim 8, further
comprising:

a first auxiliary fiducial encompassed by the first
main fiducial;

a second auxiliary fiducial encompassed by the second
main fiducial; and

a third auxiliary fiducial encompassed by the third
main fiducial.

11.   The multiple fiducial pattern of Claim 10, wherein, the
first circular main fiducial is distinguishable from the second
main fiducial due to the first auxiliary fiducial and the second
auxiliary fiducial.

12.   The multiple fiducial pattern of Claim 8, further
comprising:

a first plurality of identifying features around the
first circular main fiducial;

a second plurality of identifying features around the
second circular main fiducial; and

a third plurality of identifying features around the
third circular main fiducial.

13.   The multiple fiducial pattern of Claim 12, wherein the
first plurality of identifying features uniquely identifies the
first circular main fiducial.

14.   The multiple fiducial pattern of Claim 13, wherein the
first plurality of identifying features identifies an orientation
of the first circular main fiducial.

15.   The multiple fiducial patter of Claim 12, wherein the
first plurality of identifying features comprises:

a first group of identifying feature organized as a
first binary number identifying a first grid index; and

a second group of identifying feature organized as a
second binary number identifying a second grid index.

16.   The multiple fiducial pattern of Claim 15, wherein the
first plurality of identifying features further comprises:

a third group of identifying features organized as a
third binary number equal to the first grid offset plus one;
and

a fourth group of identifying features organized as a
fourth binary number equal to the second grid offset plus
one; and

17.   The multiple fiducial pattern of Claim 12, wherein the
all identifying features are a first color and all circular main
fiducials are a different second color.

18.   The multiple fiducial pattern of Claim 8 mounted on a portable computing platform.

19.   The multiple fiducial pattern of Claim 8, mounted on a turntable.

20.   A method of pose estimation using a primary region representing a circular main fiducial and a secondary region representing an auxiliary fiducial, the method comprising:
    calculating a plurality of moments of the primary region;
    characterizing the primary region as an ellipse based on the moments of the primary region;
    calculating a plurality of parameters for a 5D pose based on the ellipse; and
    calculating a 6D pose using the 5D pose and the auxiliary fiducial.

21.   The method of Claim 20, wherein the calculating a 6D pose using the 5D pose and the auxiliary fiducial comprises calculating a centroid of the auxiliary fiducial.

22.   The method of Claim 20, wherein the calculating a 6D pose using the 5D pose and the auxiliary fiducial comprises calculating the orientation of the auxiliary fiducial.

23.   A method of pose estimation for a plurality of regions based on a multiple fiducial pattern having a grid of main fiducials, the method comprising:
    calculating a plurality of parameters for one or more 5D poses of each region to generate a plurality of 5D poses;

grouping the 5D poses into one or more planar groups;
and

selecting the planar group with the most members as the
plane of the multiple fiducial pattern.

24. The method of Claim 23, wherein calculating a plurality
of parameters for one or more 5D poses of each region to generate
a plurality of 5D poses comprises:

calculating a pose normal for each 5D pose; and

calculating a pose center for each 5D pose.

25. The method of Claim 24, wherein grouping the 5D poses
into one or more planar groups comprises:

creating a set of planar groups wherein each planar
group has a plane normal and a plane point;

assigning each 5D pose to a planar group based on the
pose normal, the plane normal, the pose center and the plane
point.

26. The method of Claim 25, further comprising adding a new
planar group to the set of planar groups when a current 5D pose
does not fit any planar group of the set of planar groups.

27. The method of Claim 26, wherein the plane normal of the
new planar group is set equal to the pose normal of the current
5D pose.

28. The method of Claim 26, wherein the plane point of the
new planar group is set equal to the pose center of the current
5D pose.

29. The method of Claim 23, further comprising:

calculating a center difference between each pair of 5D poses to form a plurality of center differences; and

orienting the multiple fiducial pattern based on the 5D poses with a center distance that most closely equals a grid distance of the multiple fiducial pattern.

30.   The method of Claim 29, wherein orienting the multiple fiducial pattern based on a first 5D pose and a second 5D pose with a center distance that most closely equals a grid distance of the multiple fiducial pattern comprises:

assigning the center difference whose length most closely equals a grid distance as a first direction of the multiple fiducial pattern; and

assigning a cross product of the first direction with a plane normal as a second direction of the multiple fiducial pattern.

31.   The method of Claim 23, further comprising using identifying features to match one or more regions of the plurality of regions to fiducials in the multiple fiducial pattern.

32.   The method of Claim 31, wherein the identifying features provide orientation information.

33.   A system of pose estimation using a primary region representing a circular main fiducial and a secondary region representing an auxiliary fiducial, the system comprising:

means for calculating a plurality of moments of the primary region;

means for characterizing the primary region as an ellipse based on the moments of the primary region;

means for calculating a plurality of parameters for a
5D pose based on the ellipse; and

means for calculating a 6D pose using the 5D pose and
the auxiliary fiducial.

34. The system of Claim 33, wherein the means for
calculating a 6D pose using the 5D pose and the auxiliary
fiducial comprises means for calculating a centroid of the
auxiliary fiducial.

35. The system of Claim 33, wherein the means for
calculating a 6D pose using the 5D pose and the auxiliary
fiducial comprises means for calculating the orientation of the
auxiliary fiducial.

36. A system of pose estimation for a plurality of regions
based on a multiple fiducial pattern having a grid of main
fiducials, the system comprising:

means for calculating a plurality of parameters for one
or more 5D poses of each region to generate a plurality of
5D poses;

means for grouping the 5D poses into one or more planar
groups; and

means for selecting the planar group with the most
members as the plane of the multiple fiducial pattern.

37. The system of Claim 36, wherein the means for
calculating a plurality of parameters for one or more 5D poses of
each region to generate a plurality of 5D poses comprises:

means for calculating a pose normal for each 5D pose;
and

means for calculating a pose center for each 5D pose.

38.   The system of Claim 37, wherein the means for grouping the 5D poses into one or more planar groups comprises:

means for creating a set of planar groups wherein each planar group has a plane normal and a plane point;

means for assigning each 5D pose to a planar group based on the pose normal, the plane normal, the pose center and the plane point.

39.   The system of Claim 38, further comprising means for adding a new planar group to the set of planar groups when a current 5D pose does not fit any planar group of the set of planar groups.

40.   The system of Claim 39, wherein the plane normal of the new planar group is set equal to the pose normal of the current 5D pose.

41.   The system of Claim 39, wherein the plane point of the new planar group is set equal to the pose center of the current 5D pose.

42.   The system of Claim 36, further comprising:
means for calculating a center difference between each pair of 5D poses to form a plurality of center differences; and
means for orienting the multiple fiducial pattern based on the 5D poses with a center distance that most closely equals a grid distance of the multiple fiducial pattern.

43.   The system of Claim 42, wherein the means for orienting the multiple fiducial pattern based on a first 5D pose and a

second 5D pose with a center distance that most closely equals a grid distance of the multiple fiducial pattern comprises:

means for assigning the center difference whose length most closely equals a grid distance as a first direction of the multiple fiducial pattern; and

means for assigning a cross product of the first direction with a plane normal as a second direction of the multiple fiducial pattern.

44.   The system of Claim 36, further comprising means for using identifying features to match one or more regions of the plurality of regions to fiducials in the multiple fiducial pattern.

45.   The system of Claim 44, wherein the means for identifying features provide orientation information.